



Academic Research As a Career

LINUS PAULING

California Institute of Technology, Pasadena, Calif.

The real student in science—with a consuming curiosity into the laws of nature and with top scholastic status—may be of the caliber required to become the recognized authority in some field

A CAREER of academic research—research and teaching in a university or college—is the best of all possible careers, for those people who are suited to it by nature and disposition.

By academic research is meant research in pure science, research that is carried out in an effort to increase our understanding of the nature of the world in which we live. It does not have as its primary purpose the solution of any practical problem; but it is fundamental to practical progress, in that the discoveries made by the workers in pure science of one generation provide the basis for the great industries of the next generation.

The overwhelming majority of the workers in academic research are connected with universities or colleges. A smaller number are in research institutes, such as the Rockefeller Institute for Medical Research or the Johnson Foundation for Research in Biophysics at the University of Pennsylvania. Some of these research institutes are connected with universities and some not. Some of the great industrial research laboratories provide the opportunity for a few men to carry on fundamental research. Most of the people who carry on academic research also devote part of their time to teaching.

Qualities Required

The first question is: What are the qualities that determine whether a student is or is not fitted for a life of academic research? There is one all-important requirement—that he have a deep curiosity about nature, a consuming desire to know more about the world; in short, that he have the scientific spirit. He must be a scholar by disposition. It is good also, if he is to be a teacher as well as a research man, that he have a strong desire to communicate his knowledge to other people.

In addition to scholarly interest, scholarly aptitude is desirable. A brilliant student, with a penetrating mind and a phenomenal memory, has the greatest chance of being a brilliant research man, provided also that he has the scientific spirit, the urge to learn more about nature; but experience has shown us that

some men who could not be described as brilliant students have become outstanding figures in academic research. Such a man might be a gifted experimentalist, or a careful, penetrating analyst of fundamental theoretical principles.

Bailar [CHEM. ENG. NEWS, 28, 2959 (1950)] has classified careers in chemistry and chemical engineering in terms of two parameters, scholastic interest and aptitude, and interest in people and ability to handle them. He has designated research as the career that requires the maximum scholastic interest and aptitude, and the minimum interest in people. University teaching he has classified as requiring almost the maximum scholastic interest and aptitude and also a large amount of interest in and ability to handle people. We may assume that in general a student who is outstanding in both respects may be encouraged to consider a career of academic research—provided always that he is activated by the driving force of curiosity.

It is not necessary that a student be of a conventional nature in order to succeed in academic research. Success may lie in research productivity, or in effective teaching, the training of young men for scientific careers, or in any combination of these two activities; and the positions available for academic research men vary so much in nature that the man with small gifts as a teacher, but with outstanding research ability, and the man with a keen interest in the scientific world and in the instruction of students, and yet with small desire to obtain new

knowledge through his own efforts, may both be successfully fitted into academic life. It is indeed true that the popular conception of both the professor and the scientist is that they are freaks; we know that this conception does not hold in general, and that even the academic research man, the combination of professor and scientist, is usually a well balanced, conventional citizen; and yet there is a place in academic research for the unusual character, and, indeed, we note that it is often the unusual man who makes the most surprising and fundamental discoveries.

In the discussion of the graduate training of chemists, the article of Adams, Fuson, and Marvel [CHEM. ENG. NEWS 28, 2765 (1950)] has said that the trained research man of highest type has the fundamental traits of originality, ingenuity, and imagination, which cannot be given to a student by graduate training, although they can be developed, and that in addition he has original ideas, discretion in the choice of what ideas to follow, and the patience and drive to finish the pursuit without jumping from one project to another. All of these qualities are important to the academic research man.

Fields of Research

A young man who enters academic research should develop his own *field of research* as early in his career as is possible. He should strive to work independently; one of the most attractive features of the academic life is the freedom of investigational activity that the aca-



LINUS CARL PAULING, chairman of the division of chemistry and chemical engineering at CalTech and director of Gates and Crellin Laboratories of Chemistry, whose list of top honors includes the presidency of the ACS (1949), has won most of the important awards in the chemical world. Among them are the First ACS Award in Pure Chemistry, and the Nichols, Gibbs, Richards, and Davy medals. He became interested in atomic structure and began experimental work in that field at 20 years of age, and since then his interests have covered all branches of chemistry. His reputation as a theoretical chemist is international. He has predicted that knowledge of structure may aid in the solution of such medical research problems as cancer.

The above article is listed as Contribution No. 1483 from the Gates and Crellin Laboratories of Chemistry.

ademic man has. In general, the academic research man in a university has the right to make decisions about the nature of the research that he will carry on, and the way in which the problems will be attacked. In recent years it has become necessary to have large and expensive pieces of apparatus in order to attack certain problems. A member of a team operating a complex apparatus in the attack on a difficult problem does not have the freedom of decision about his research that an independent worker has. It is my opinion that in general this sort of engineering teamwork is not suited to universities, and that the academic research man should avoid the fields of work of this sort in which he would have to sacrifice his independence. He may, of course, make use in his work of isotopes provided by a uranium pile, or he may collaborate with colleagues in the medical school in order to obtain materials for his studies, but he should not sacrifice his independence of action over any extended period.

The goal of the academic research man should be to become the authority in a field of knowledge. It is evident that, since we have in this country some thousands of academic research men in chemistry and chemical engineering and related fields, not every one of them can become the outstanding authority in a major field. On the other hand, to limit the field in an extremely narrow way would be undesirable, if it restricted the breadth of his interests. I believe that the best general solution that can be found to this problem is the following: the academic research man should be broad in his interests, and should, in case the facilities available to him permit it, carry on an investigational program along several lines—he should have more than one interest; and in addition, he should devote a considerable fraction of his efforts to one field, perhaps a rather narrow field, of which he should become, after some time, the recognized master.

Attractive Aspects of the Career

The primary reason for a man to go into a life of academic teaching and research is that it provides him with an opportunity for carrying on researches in pure science in the fields in which he himself is interested. There are other advantages to academic life that might well appeal to him. The vacation periods are in general much longer than those for employees in industrial or governmental work, and he may use these periods for following up a second interest—another field of science, or even a different scholarly field. Moreover, the academic life offers an opportunity for writing books, which may be scientific monographs, textbooks of science, or even non-technical books. Finally, academic research offers greater opportunities for travel than are offered by most other careers. It is important for the research man to travel, in order to find out how problems are being tackled in other universities and research laboratories, to learn more about the world generally, and to

get acquainted with the other people who are making contributions to science. Herodotus said that it is the scholars who should be travelers—and this statement is just as valid now as 2,000 years ago.

Disadvantages

The principal disadvantage of a life of academic research is that the income received by a man in this field is significantly less than that which he would receive in other fields of activity. I shall illustrate this point by quoting some numerical values; these values are not to be taken as representing reliable averages at the present time, but instead as indicating relative values, with reasonable validity. A young man who has just received his Ph.D. in chemistry and who is suited to an academic appointment—who might, in general, be classed as being in the upper third of the group of young Ph.D.'s—may expect to receive appointment in a university as instructor or postdoctoral fellow, with annual salary \$3,600, whereas if he were to be given an industrial appointment his salary might be \$4,500 or \$4,800. As the years go by he could expect to be promoted to an assistant professorship, then to an associate professorship, and then to a full professorship in chemistry. As a full professor his salary would lie in the range between about \$5,000 (even somewhat less in some colleges) and \$10,000 or \$12,000, with a rather small percentage in the latter group. In a government laboratory his salary might be somewhat larger; in industrial work it would, on the average, be considerably larger—even by 50 or 100%.

The academic man may increase his salary somewhat through royalties from the sale of books, or through work as consultant for industrial firms. However, he should not plan to obtain a great amount of income from consulting work, because the time devoted to the work might become so large as to interfere seriously with his primary career, of teaching and research in pure science. He should in particular be on guard against the danger of becoming involved in jobs of applied research for industry.

The smaller salary received by the academic research man is such a significant disadvantage that the young chemist or chemical engineer may well ask what possible justification there could be for his decision to follow this career. The answer is that the compensating advantage of freedom to carry on independent research is so great for a man who is deeply imbued with the scientific spirit as to make it worth while to accept the decreased salary.

Preparing for This Career

The training that a student should obtain in preparation for a life of academic teaching and research should be as broad as possible and as fundamental as possible. The student should concentrate on the basic scientific subjects, including mathematics, and on broadening cultural subjects; in general, he should ignore technical subjects of ephemeral value.

Languages are important, and the student should learn languages as early in his life as possible, preferably beginning in high school. German is essential. A reading knowledge of French should also be obtained and an opportunity to learn something about Spanish, Italian, or other European languages should not be ignored. In recent years increasingly important scientific contributions have been appearing in Russian.

Every man who plans to make a career in the academic research field should carry on graduate work leading to the Ph.D. degree. The qualities that are necessary for success in this field should justify his appointment as a graduate assistant or teaching fellow in a university. Appointments of this sort carry on the average stipends of about \$100 per month at the present time, plus a grant for tuition. In return the assistant or fellow is required to spend about 15 hours per week in assisting with the teaching of elementary subjects to undergraduates, or in correcting papers or working in the stockroom. On such an appointment it is usually possible for a man to carry a full load of graduate work, and to obtain the Ph.D. degree in three or four years. He may supplement his income by taking a job during the three summer months; or he may be successful in obtaining an appointment at about the same stipend as during the academic year, that will permit him to continue his graduate work, especially his research, through the summer.

A graduate student should devote between one quarter and one half of his time to research, and the remainder of his time to attendance at formal graduate courses and seminars. He should take some course work in related subjects, such as physics, mathematics, and biology, as well as in chemistry. It is especially important for a man who is going into academic research not to specialize narrowly.

During his graduate student period and his early postdoctoral years he should attend as many seminars as possible, in his own and other fields of chemistry and in the related sciences, at which the current literature and new discoveries are discussed.

In the past it has been customary in many universities for a graduate student to select his research professor either at the beginning of his first year of graduate work or toward the end of this year, and to plan to carry on research with this professor throughout his graduate period. In recent years the wise policy has been introduced in many universities of encouraging graduate students to prepare a doctoral thesis containing two, three, or four parts, representing work carried out along several different research lines, in collaboration with or under the supervision of different staff members. The broadening research experience obtained in this way is especially valuable to a young man who is preparing for independent work in pure science.

NEXT week's "Careers" article will be written by Howard Maple and will discuss technical writing.